TECHNICAL REPORT

70-36-FL

AD

STUDIES ON REVERSIBLE COMPRESSION OF DEHYDRATED VEGETABLES

by

Abdul R. Rahman

Glenn Schafer

George R. Taylor

Donald E. Westcott

November 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Laboratory

FL-102

This document has been approved
for public release and sale; its
distribution is unlimited

AD________________

TECHNICAL REPORT
70-36-FL

STUDIES ON REVERSIBLE COMPRESSION OF DEHYDRATED VEGETABLES

by

Abdul R. Rahman
Glenn Schafer
George R. Taylor
Donald E. Westcott

Project reference
1J6-62708-D553

Series: FL-102

Food Laboratory
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts 01760

FOREWORD

Compressed dehydrated foods offer significant reduction in volume and weight. Therefore, such foods are of significant value in the Armed Forces in reducing storage and transportation requirements. It is particularly important for military operations where a food supply must be carried by the soldier. Another important application for compressed dehydrated foods is in space missions. This report covers developmental studies of the reversible compression of vegetables, i.e., those which can be compressed and subsequently restored to their normal appearance and texture by rehydration.

The work was conducted under Project No. 1J6-62708-D553, Food Processing and Preservation Techniques.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Compressed bars approximately 3 x 1 x 1/2 inches have been developed from freeze dried, peas, corn, spinach, carrots, green beans, as well as air dried sliced onions. Rehydration ratio and texture as measured by shear press were not significantly affected by compression. Compression ratios obtained were: peas 1:4, corn 1:4, sliced onions 1:5, spinach 1:11, carrots 1:14 and green beans 1:16.

Introduction

Dehydration is a highly acceptable process for the preservation and reduction of weight of foods. However, there is minimal reduction in volume (or increase in density) from dehydration. For military usage, it has become increasingly important to compact such foods to reduce handling, storage and transportation costs.

Various fruits and vegetables have been compressed and subsequently restored to their normal appearance and texture through rehydration. Hamdy (1961) indicated that obtaining acceptable products from compression of foods varies. Gooding and Rolfe (1957) reported that reduction in volume of up to 8-fold was obtained by compressing dehydrated vegetables. During World War II, the United Kingdom produced dehydrated cabbage and carrots in compressed blocks. Fairbrother (1968) reported on the compression of potato granules at a low moisture content and the compression of an instant bread mix.

Hamdy (1962) found that acceptable compressed freeze-dried spinach could be obtained by increasing the plasticizing moisture content to 9 percent. Ishler (1962) reported that spraying the dehydrated food with water, glycerine or propylene glycol before compression produced bars with excellent rehydration characteristics. He also found that successful compressed food can be achieved by spraying freeze-dried cellular foods to 5-13 percent moisture, compressing, and redrying to less than 3 percent moisture. Lampi (1963) indicated that high pressures during compression resulted in high density food disks which were hard and/or were difficult to rehydrate. The moisture level of the food prior to compression also affected rehydration. Brockmann (1966) reported that freeze-dried foods, properly preconditioned, can be compressed with little or no fragmentation and that most foods so compressed can be restored to their pre-compression characteristics. This work was initiated in order to determine the effect of compression on the texture of dehydrated vegetables. Furthermore, to determine their compression ratios as criteria for possible savings in cost of packaging materials, handling, storage and transportation.

Experimental Procedures

Product Preparation

All products were locally purchased. Compression was accomplished on a Carver press using compression forces of 500, 1000, 1500, 2000, and 2500 pounds per square inch (p.s.i.).

Peas: Individually quick frozen (IQF) peas were partially thawed and the seed coat was mechanically slit at several points in order to facilitate the removal of water during freeze-drying. The peas were sulfited by dipping in solution of sodium metabisulfite to yield approximately 400 ppm. They were frozen at -20°F. and then freeze dried at a platen temperature of 120°F. to a final moisture content of less than 2 percent. The freeze dried peas were subjected to live steam for 5 minutes. Approximately 20 grams of peas were compressed to bars approximately 3 x 1 x 1/2 inches.

Corn: Corn was freeze dried with a platen temperature of 120°F. to a final moisture content of less than 2 percent. The freeze dried corn was sprayed with water until weight was increased by 12 percent. The sprayed corn was then heated in a closed container for 10 minutes at 200°F. to equilibrate the moisture in the corn. The corn was then compressed.

Spinach: Frozen spinach was thawed and sulfited by dipping in a solution of metabisulfite to yield approximately 500 ppm. It was then freeze dried with a platen temperature of 120°F. for 16 hours. The freeze dried spinach was subjected to live steam for 5 minutes and then compressed. Each bar weighed approximately 10 grams.

Onions: Sliced onions were air dried in accordance with Specification JJJ-O-533. They were subjected to live steam for 5 minutes and then compressed.

Green beans: Cross cut frozen green beans were freeze dried and compressed following the procedure used for the spinach.

Carrots: Fresh carrots were lye peeled and cut into dice 3/8 x 3/8 x 1/16 inches. The carrots were steam blanched for 10 minutes in order to inactivate the enzyme, peroxidase. The carrots were then sulfited by dipping in a solution of metabisulfite to yield approximately 400 ppm. They were then frozen at -20°F. and freeze dried with a platen temperature of 120°F. for 16 hours. They were then compressed following the procedure used for the spinach.

All the compressed bars were redried using a vacuum oven to reduce the final moisture content to approximately 2 percent.

Rehydration Ratio: Rehydration ratio was determined by dividing the rehydrated weight by the dry weight. The following rehydration procedures were used.

Corn and peas: Each bar was placed in approximately 500 ml of 210°F. water, held for 12 minutes and then drained for 5 minutes.

Carrots: Each bar was placed in approximately 500 ml of boiling water, boiled for 1 minute and soaked for another minute and then drained for 5 minutes.

Onions: Each bar was placed in approximately 500 ml of boiling water, boiled for 5 minutes, and then drained for 5 minutes.

Spinach: Each bar was placed in approximately 500 ml of water at 210°F., held for 3 minutes, and then drained for 5 minutes.

Green beans: Each bar was placed in approximately 500 ml of water at 210°F., held for 15 minutes and then drained for 5 minutes.

Compression ratio: To determine compression ratios, the dehydrated vegetables were compressed into discs approximately of 4" diameter, so that they would fit a No. 2-1/2 can. The compression force for each product was selected in accordance of their physical appearances, shedding time, and rehydration ratio; for example the following forces (pounds per square inch) were applied, 1500 for peas, corn, carrots and onions, and 1000 for spinach. The compressed discs required to fill a No. 2-1/2 can, leaving approximately 1/4" headspace, were weighed. Uncompressed freeze dried or air dried product of equivalent weight to that of the compressed was packed loosely in No. 2-1/2 cans leaving approximately 1/4" headspace. The number of cans utilized to pack the loose product gave the compression or packaging ratio.

Bulk density was measured by dividing the weight of the loose or compressed product by its respective volume to yield grams per cubic centimeter. Calculated compression ratio was then determined by dividing the bulk density of the compressed product by that of the uncompressed.

Shedding time was measured by placing the compressed product in hot water approximately 210°F., and then reporting the time at which all the individual pieces separate from the compressed product. Texture of rehydrated product was measured immediately after rehydration with the Lee-Kramer shear press using the 5000-pound ring with 30 seconds downstroke.

Results and Discussion

Tables 1 through 6 give the texture and rehydration ratio for each of the compressed vegetables. There data indicate that compression forces used did not produce significant differences in rehydration ratio or texture as measured by the shear press. However shedding time increased somewhat as the compression force increased. This suggests that shedding time may reflect the degree of cohesiveness as a criterion for the ability of compressed products to withstand abuse during handling, storage and transportation.

Table 7 indicates that compression ratio, as determined by actual filling of the cans, is slightly lower than that calculated from the bulk densities. This is due to the allowances given to headspace, the space between the compressed discs and the can wall needed to facilitate packing and unpacking of the product, and space between the discs due to uneven surface caused by relaxation of the product after compression.

Figures 1 through 6 show the practical compression ratios of 1:4, 1:4, 1:5, 1:11, 1:14 and 1:16 for peas, corn, onions, spinach, carrots and green beans respectively.

References

1. Gooding, E. B. B. and Rolfe, E. J. Some recent work on dehydration in the United Kingdom. Food Technol. 11, 302-6, Chicago, Illinois 1957.

2. Hamdy, M. M., Compression of dehydrated foods. Review of Literature. Contract No. DA 19-129-QM-1630. Quartermaster Food and Container Institute for Armed Forces, Chicago, Illinois 1960.

3. Hamdy, M. M., Compression of dehydrated food. Final Report. Contract No. DA 19-129-QM-1899. Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois 1962.

4. Ishler, N.I., Methods for controlling fragmentation of dried foods during compression. Final Report. Contract No. DA 19-129-AMC-2 (X), Technical Report D-13. U. S. Army Natick Laboratories, Natick, Massachusetts 1965.

5. Lampi, R. A. Development of Built-In-Mechanisms for Softening and Rehydrating Compacted Foods. Contract No. DA 19-129-AMC-44 (X). Armed Forces Food and Container Institute. U.S. Army Quartermaster Research and Engineering Center, Chicago, Illinois 1963.

6. Brockmann, Maxwell C. Compression of Foods - Activities Report 18 (2), 173-177, 1966.

7. Fairbrother, J. G. and Smith, S. W. C. Compressed Dehydrated Foods. Report No. 1/68, Australian Military Forces, Food Research Station, Scottsdale, Tasmania 1968.

8. ----------------. Onions, Dehydrated, Federal Specification, JJJ-O-533b, 1962.

Table 1. Texture and Rehydration Ratio of Dehydrated Peas as Affected by Compression

Compression Pressure PSI (Pounds sq. inch)	Rehydration Ratio Rehydrated weight/dry weight*	Shear Press Value after Rehydration Pounds*	Shedding Time Minutes
500	4.26	279	1
1000	4.46	283	3
1500	4.24	287	3
2000	4.30	309	4
2500	4.69	309	4-1/4

* No significant difference at [illegible]% level.

Table 2. Texture and Rehydration Ratio of Dehydrated Corn as Affected by Compression

Compression Pressure PSI (Pounds sq. inch)	Rehydration Ratio Rehydrated weight/dry weight*	Shear Press Value after Rehydration Pounds*	Shedding Time Minutes
500	2.8	277	4
1000	2.7	270	4
1500	2.7	307	4
2000	2.8	282	4-1/2
2500	2.9	330	5

* No significant difference at 5% level.

Table 3. Texture and Rehydration Ratio of Dehydrated Onions as Affected by Compression

Compression Pressure PSI (pounds sq. inch)	Rehydration Ratio Rehydrated weight/dry weight*	Shear Press Value after Rehydration Pounds*	Shedding Time Minutes
500	4.8	175	30
1000	4.7	186	40
1500	4.9	174	60
2000	4.9	172	70
2500	4.8	141	90

* No significant difference at 5% level.

Table 4. Texture and Rehydration Ratio of Dehydrated Spinach as Affected by Compression

Compression Pressure PSI (Pounds sq. inch)	Rehydration Ratio Rehydrated weight/dry weight*	Shear Press Value after Rehydration Pounds*	Shedding Time Minutes
500	8.9	105	10
1000	8.8	116	10
1500	7.9	120	25
2000	7.4	102	30
2500	7.6	117	30

* No significant difference at 5% level.

Table 5. Texture and Rehydration Ratio of Dehydrated Carrots as Affected by Compression

Compression Pressure PSI (Pounds sq. inch)	Rehydration Ratio Rehydrated weight/dry weight*	Shear Press Value after Rehydration Pounds*	Shedding Time Minutes
500	15.2	195	1/2
1000	15.8	175	1/2
1500	15.4	195	3/4
2000	15.2	165	3/4
2500	14.0	182	1

* No significant difference at 5% level.

Table 6. Texture and Rehydration Ratio of Dehydrated Green Beans as Affected by Compression

Compression Pressure PSI (Pounds sq. inch)	Rehydration Ratio Rehydrated weight/dry weight*	Shear Press Value after Rehydration Pounds*	Shedding Time Minutes
500	10.9	141	2
1000	11.4	114	3
1500	11.0	142	3
2000	11.7	180	3-1/2
2500	11.8	149	3-1/2

* No significant difference at 5% level.

Table 7. Bulk Densities of Air Dried and Freeze Dried Vegetables before and after Compression

Product	gms/cc Freeze Dried	gms/cc Compressed	Compression Ratio Calculated from Bulk Densities	Compression Ratio Measured by Actual Fill of Cans
Peas	0.216	.889	4.1	4
Corn	0.192	0.810	4.2	4
Onions	0.190	1.010	5.3	5
Spinach	0.038	0.419	11.3	11
Carrots	0.036	0.530	14.7	14
Green Beans	0.038	0.615	16.3	16

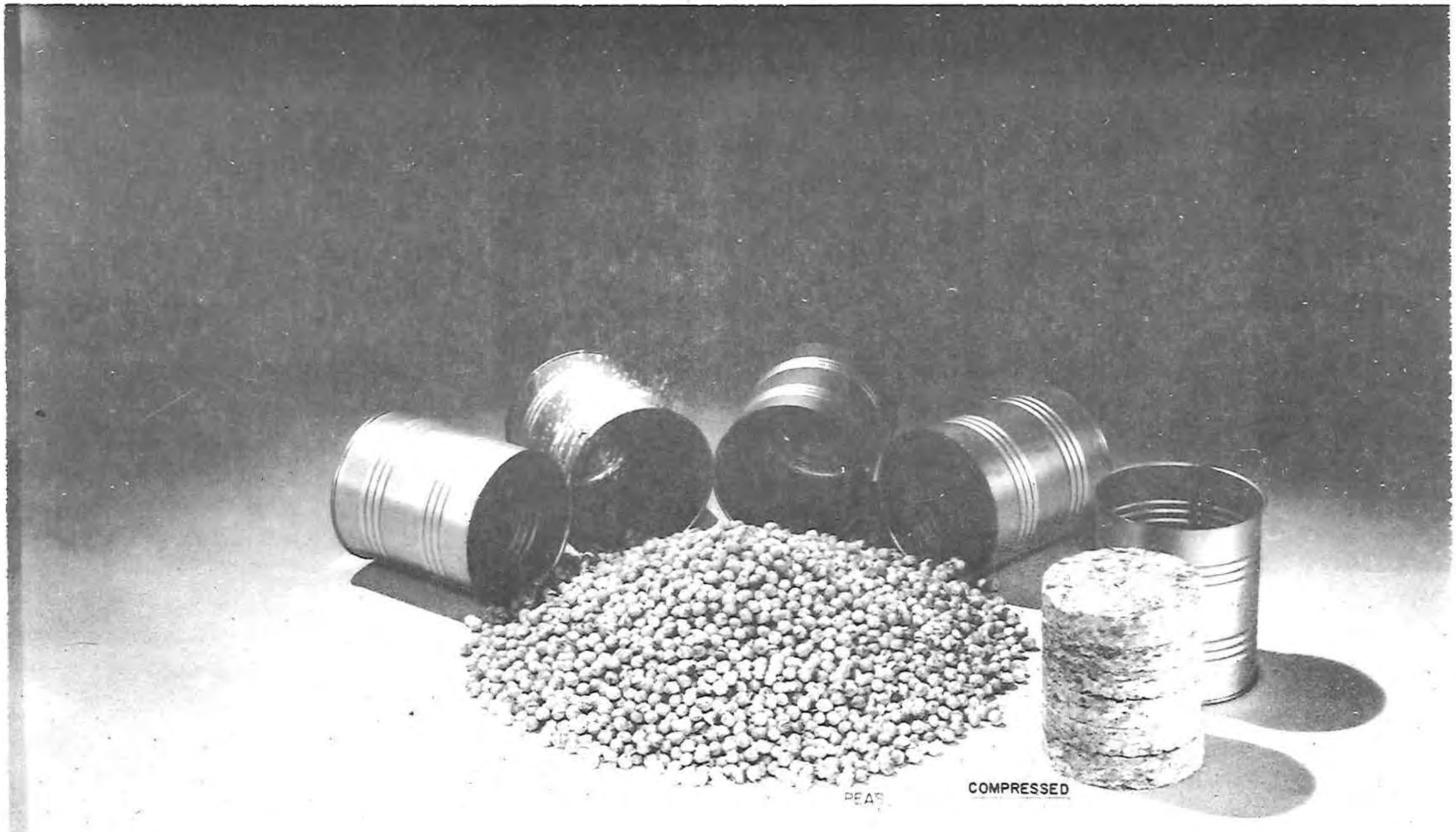

Figure 1. Freeze Dried Peas Obtained from 4 Cans are Compressed into 1 Can.

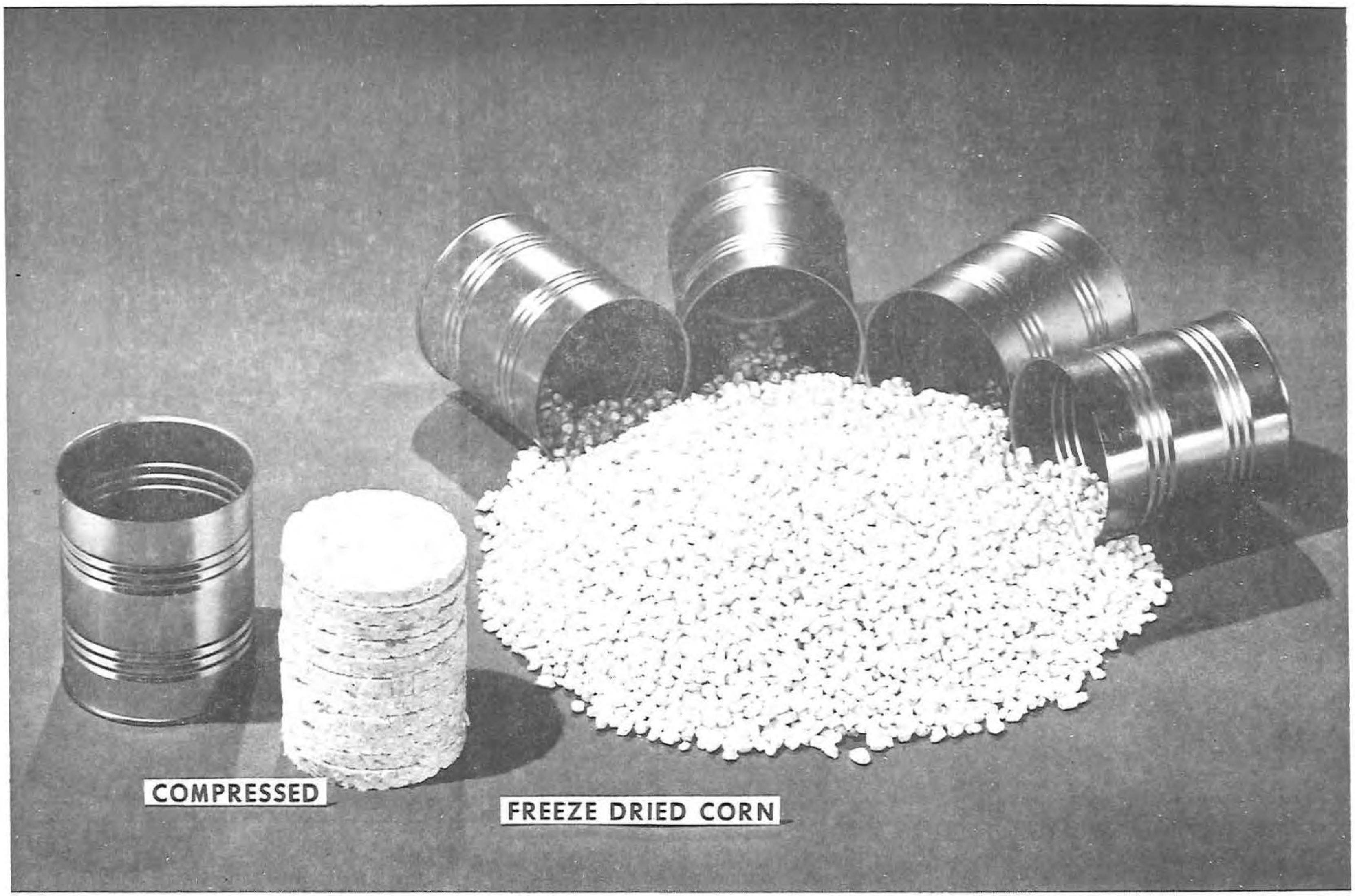

Figure 2. Freeze Dried Corn Obtained from 4 Cans are Compressed into 1 Can.

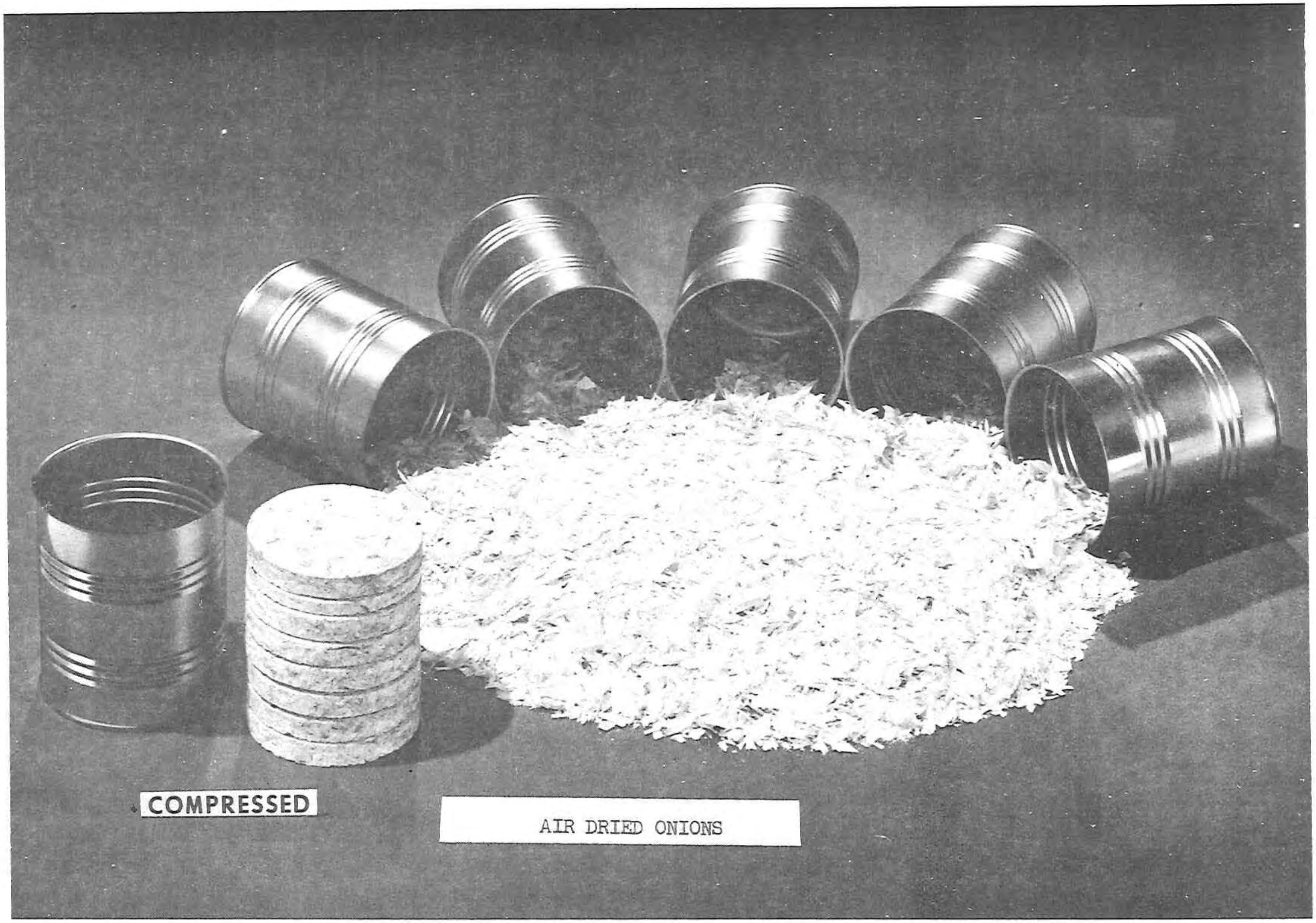

Figure 3. Air Dried Sliced Onions Obtained from 5 Cans are Compressed into 1 Can.

Figure 4. Freeze Dried Spinach Obtained from 11 Cans are Compressed into 1 Can.

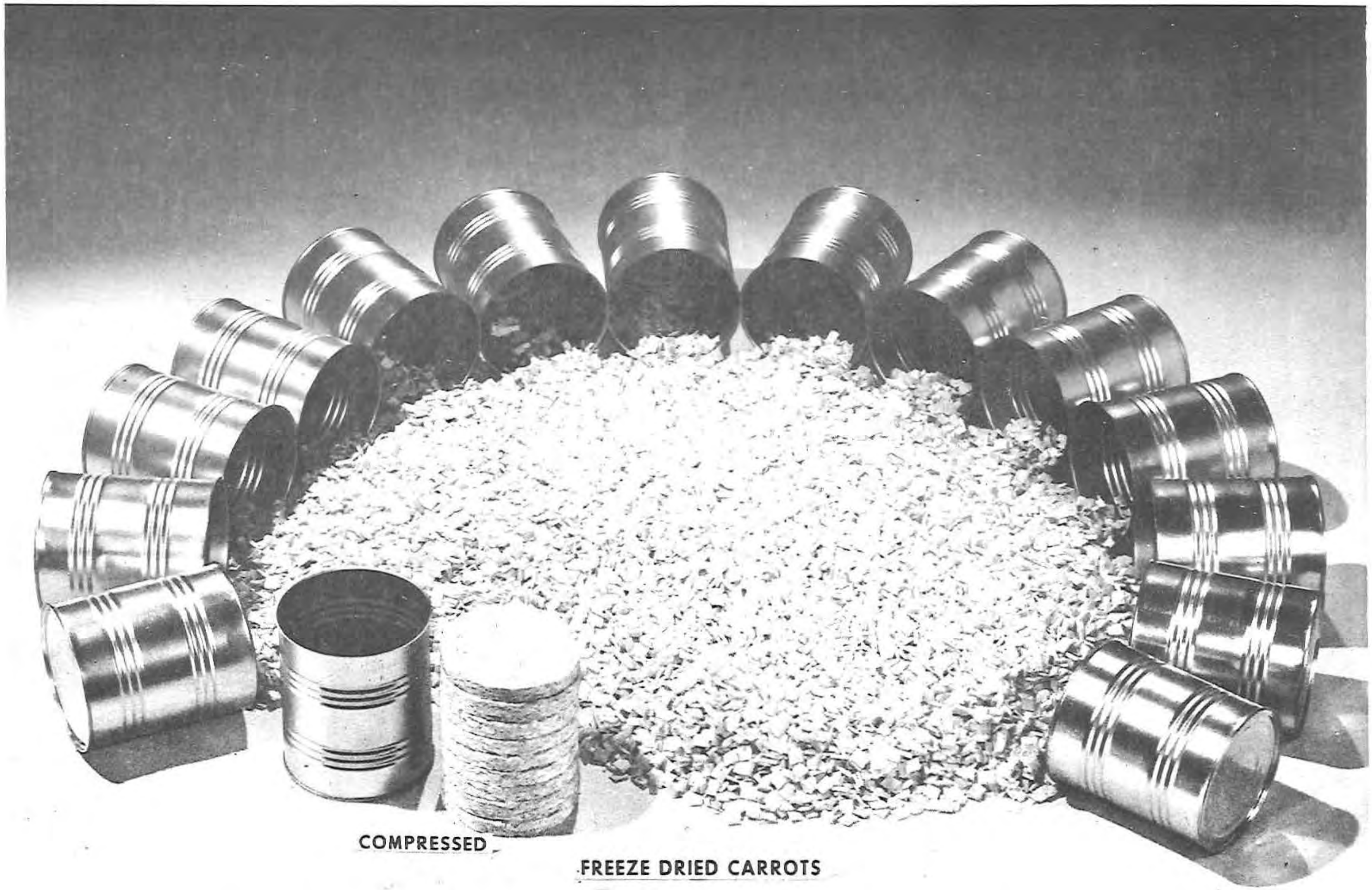

Figure 5. Freeze Dried Carrots Obtained from 14 Cans are Compressed into 1 Can.

Figure 6. Freeze Dried Green Beans Obtained from 16 Cans are Compressed into 1 Can.

FOOD LABORATORY DISTRIBUTION LIST - PLANT PRODUCTS

Copies

1- Commanding General
US Army Medical Research and
Development Command
ATTN: MEDDH-SI
Washington, D.C. 20315

2- Commanding General
US Army Test and Evaluation
Command
ATTN: AMSTE-BC
Aberdeen Proving Ground
Maryland 21005

1- Commanding General
US Army Combat Development
Command
Combat Service Support Group
Fort Lee, Virginia 23801

1- Commanding General
US Army Combat Development
Command
ATTN: CDCMR-O
Fort Belvoir, Vriginia 22060

1- Commanding General
US Army Materiel Command
ATTN: AMCRD-JI
Department of the Army
Washington, D. C. 20315

2- Commanding Officer
Edgewood Arsenal
ATTN: SMUEA-TSTI-TL
Edgewood Arsenal, Maryland 21010

1- Commanding Officer
US Army Combat Development
Command
Supply Agency
ATTN: CDCSA-R
Fort Lee, Virginia 23801

Copies

1- Commanding Officer
US Army Medical Nutrition
Laboratory
Fitzsimons General Hospital
Denver, Colorado 80240

1- Commander
Defense Personnel Support
Center
ATTN: Directorate of
Subsistence, DPSC-STS
2800 South 20th Street
Philadelphia, Pennsylvania 19101

1- Commandant of the Marine Corps
Code A04D
Washington, D. C. 20380

1- Commandant of the Marine Corps
Code CDE
Washington, D. C. 20380

2- Executive Secretary
Interdepartmental Committee on
Radiation Preservation of
Food
Consumer Products Division 623
Business and Defense Service
Administration
Washington, D. C. 20230

2- Director
Development Center
Marine Corps Development and
Education Command
ATTN: Combat Service Support
Division
Quantico, Virginia 22134

Copies

1- Director
Division of Biology and Medicine
US Atomic Energy Commission
Washington, D. C. 20545

1- Director
US Army Advanced Materiel Concepts Agency
Washington, D. C. 20315

1- Chief, Life Sciences Division
Army Research Office
Office of Chief of Research and Development
Washington, D. C. 20310

3- Office of the Coordinator of Research
University of Rhode Island
Kingston, Rhode Island 02881

1- Dr. Herbert E. Hall
Chief, Food Microbiology
National Center for Urban and Industrial Health
Food Protection Research
222 East Central Parkway
Cincinnati, Ohio 45202

1- Library Southern Utilization Research and Development Division
Agricultural Research Service
US Department of Agriculture
PO Box 19687
New Orleans, Louisiana

Copies

1- Stimson Library
ATTN: Documents Librarian
US Army Medical Field Service School
Brooke Army Medical Center
Fort Sam Houston, Texas 78234

2- Quartermaster School Library
US Army Quartermaster School
Fort Lee, Virginia 23801

2- Technical Library
USACDC Institute of Land Combat
301 Taylor Drive
Alexandria, Virginia 22314

1- US Department of Agriculture
Division of Acquisitions
National Agriculture Library
Washington, D.C. 20250

2- US Army Research Office
ATTN: Technical Library
3045 Columbia Pike
Arlington, Virginia 22204

2- Headquarters 12th Support Brigade
ACofS Services
ATTN: Food Advisor
Fort Bragg, North Carolina 28307

4- Exchange and Gift Division
Library of Congress
Washington, D.C. 20540

FOOD LABORATORY INTERNAL DISTRIBUTION LIST -PLANT PRODUCTS

Copies

25 - Chief, Technical Plans Office, NLABS
(20 for transmittal to Defense Documentation Center)

2 - Technical Library, NLABS

10 - Program Coordination Office, Food Laboratory, NLABS

7 - Division Chiefs, Food Laboratory, NLABS

2 - Marine Liaison Officer, NLABS

3 - Air Force Liaison Officer, NLABS

1 - Director, Earth Sciences Laboratory, NLABS

2 - Director, General Equipment and Packaging Laboratory, NLABS

3 - Director, Pioneering Research Laboratory, NLABS

\- Project Officer, and Alternate Project Officer, Food Laboratory, NLABS

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) US Army Natick Laboratories Natick, Massachusetts 01760	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Studies on Reversible Compression of Dehydrated Vegetables

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Abdul R. Rahman, Glenn Schafer, George R. Taylor, and Donald E. Westcott

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1969	18	8

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) 70-36-FL
b. PROJECT NO. 1J6-62708-D553	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	FL-102

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY US Army Natick Laboratories Natick, Massachusetts 01760

13. ABSTRACT

Compressed bars approximately 3 x 1 x 1/2 inches have been developed from freeze dried peas, corn, spinach, carrots, green beans, as well as air dried sliced onions. Rehydration ratio and texture as measured by shear press were not significantly affected by compression. Compression ratios obtained were: peas 1:4, corn 1:4, sliced onions 1:5, spinach 1:11, carrots 1:14 and green beans 1:16.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Development	8				8	
Fabrication	8				8	
Compressing	8		6		8	
Freeze dried foods	1		6			
Peas	1,2					
Corn	1,2					
Spinach	1,2					
Carrots	1,2					
Green beans	1,2					
Blueberries	1,2					
Cherries	1,2					
Dried foods					1,2	
Onions					1,2	
Food bars	2		7		2	